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INHERITANCE OF DEGREE OF SILVERING IN FOXES

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DESCRIPTION OF SILVERING

The silvering of a black-silver fox is produced by white areas (usually bands) toward the outer ends of the guard hairs, which extend beyond the underfur. The black parts of the guard hairs and the dark slate-colored underfur by contrast with the white areas intensify the silvery effect. White bands are present also in the guard hairs of the red fox, of which the black-silver fox is a mutant, the red pigment being replaced by black. In the early development of silver fox raising, the darker the fox pelt the more desirable it was, but the skill of the dyer in transforming a red fox pelt to a black-silver by dyeing and pointing 1/soon surpassed nature's method of producing silver fox pelts. A better and a cheaper skin came from the dye vats than could be produced by the most expert breeding. It was impossible, however, to imitate successfully the lighter silvers.

The degree of silvering may depend on several factors, the most important being the relative abundance over the entire skin of guard hairs having varying widths of white bands. The greater the amount of white, the lighter the silver. In extremely light silvers practically all the guard hairs have wide white bands or are entirely white except for short black tips. The length of these black tips in conjunction with whatever entirely black guard hairs there are determines the extent of veiling. The palest silvers have the minimum of this veiling. It is said that the extra pale pelts now being produced have shorter and coarser guard hairs

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1/ Pointing is a trade term for the process of inserting and gluing in a pelt individual guard hairs of a desired color.

than those of the earlier darker silvers, but this point has not been carefully studied. The greatest diameter of a guard hair is in the part that extends beyond the underfur, and when the white area occurs at that place, the greater is the amount of white area in relation to the black, hence more silver.

#### BRIGHT FULL SILVERS IN GREATEST DEMAND

In the United States the full silver pelts for many years have been commanding a substantial premium over other silvers. Other things being equal, the brightest of the full silvers bring the most money. This inducement has caused the more progressive fox farmers at the present time so to select and mate their animals as to produce a pup crop containing 80 percent or more of full silvers. This rapid change has been brought about partly by selective inbreeding or by line-breeding and partly by mating unrelated animals selected for high silvering.

The effectiveness of inbreeding in establishing quickly a true breeding type is well known. Records show that certain families of foxes developed by inbreeding now produce 100-percent full silvers. Such families yield the maximum revenue so long as the bright full silver pelts are popular.

Realizing that the vogue for bright silvers may be but temporary, however, some of the more cautious fox men have avoided inbreeding. But in order to take advantage of the present demand for the bright full silvers and yet protect themselves from the whims of fashion, some breeders have adopted a system of selective outcrossing. The purpose of the present study was to analyze this particular system of breeding as an effective means of catering to the popular demand yet providing insurance for the future.

#### DATA ON 638 MATINGS OF SILVER FOXES

Through the cooperation of the Associated Fur Farms, New Holstein, Wisconsin, their 1935 and 1936 breeding records were made available to the writer for detailed study. At that time that farm studiously avoided all inbreeding and line-breeding. (In more recent years some line-breeding has been done.) An infusion of the darker full silvers is constantly maintained and a few high-quality three-fourths silvers are retained for breeding. The purpose is to obtain a rich veiling in connection with the fine, full-furred pelt which it is believed the darker animals are best fitted to contribute. Matings are made on the basis of the silvering in evidence about the middle of October. The breeding animals are classified as extra bright full silver, bright full silver, full silver 2/, dark full silver, three-fourths silver, and half silver.

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2/ The term "full silver" was used for those breeding animals for which a more specific description was not available, since 1936 was the first year in which the more detailed descriptions were employed.

TABLE 1.—The number, sex, and percentage degree of silvering of the pups from 638 selected matings of silver foxes

XBS—Extra bright silver  
BS—Bright silver

SIL—Silver  
DS—Dark silver

3/4—Three-fourths silver  
1/2—Half silver

MATED ANIMALS HAVING SAME DEGREE OF SILVER

Litters				Male pups								Female pups									
Num- ber	Average size	Sire	Dam	Full silver					Darker silver				Full silver					Darker silver			
				XBS	BS	SIL	DS	Percent	3/4	1/2	1/4	Percent	XBS	BS	SIL	DS	Percent	3/4	1/2	1/4	Percent
1	4.00	XBS	XBS	-	1	-	-	100.0	-	-	-	-	2	-	1	-	100.0	-	-	-	-
68	4.75	BS	BS	20	39	39	35	72.3	26	24	1	27.7	23	37	51	16	91.4	10	2	-	8.6
15	4.53	SIL	SIL	-	9	13	9	75.6	8	2	-	24.4	2	5	14	3	88.9	1	2	-	11.1
92	4.29	DS	DS	4	16	54	30	51.2	56	43	-	48.8	2	36	83	13	69.8	45	13	-	30.2
17	5.29	3/4	3/4	-	-	6	2	22.2	12	14	2	77.8	-	4	18	5	50.0	11	15	1	50.0

EXTRA BRIGHT SILVERS MATED TO LESSER SILVERS

5	5.00	XBS	BS	3	6	3	-	92.3	1	-	-	7.7	3	2	6	-	91.7	1	-	-	8.3
4	4.75	BS	XBS	2	1	2	4	89.9	1	1	-	18.1	-	3	4	-	87.5	1	-	-	12.5
3	4.33	XBS	DS	-	1	3	1	71.4	2	-	-	28.6	2	1	1	1	83.3	-	1	-	16.7
5	3.80	DS	XBS	2	-	3	2	70.0	1	2	-	30.0	-	5	1	3	100.0	-	-	-	-
4	4.00	XBS	3/4	-	3	5	2	71.4	2	2	-	28.6	-	-	2	-	100.0	-	-	-	-
4	3.75	3/4	XBS	-	1	3	-	66.7	1	1	-	33.3	-	4	4	-	88.9	-	1	-	11.1
1	2.00	1/2	XBS	-	2	-	-	100.0	-	-	-	-	-	-	-	-	-	-	-	-	-

BRIGHT SILVERS MATED TO LESSER SILVERS

10	4.30	BS	SIL	4	4	3	4	71.4	6	-	-	28.6	-	3	13	-	72.7	6	-	-	27.3
14	5.28	SIL	BS	1	6	20	5	76.2	4	6	-	23.8	2	5	17	3	84.4	2	3	-	15.6
69	4.74	BS	DS	1	30	53	21	66.0	34	18	2	34.0	9	24	79	26	82.1	18	12	-	17.9
120	5.09	DS	BS	14	39	93	64	67.1	60	42	1	32.9	23	54	128	39	81.9	28	26	-	18.1
20	5.65	BS	3/4	1	3	14	3	35.0	20	15	4	65.0	3	8	15	8	64.2	11	6	2	35.8
36	4.58	3/4	BS	2	5	22	13	53.2	24	10	3	46.8	3	18	30	14	75.6	16	5	-	24.4
1	5.00	BS	1/2	-	-	-	-	-	1	3	-	100.0	-	-	1	-	100.0	-	-	-	-
4	4.75	1/2	BS	-	-	3	2	45.4	4	2	-	54.6	1	-	5	1	87.5	1	-	-	12.5

SILVERS MATED TO LESSER SILVERS

30	4.60	SIL	DS	2	7	26	6	58.6	23	6	-	41.4	3	4	32	9	70.6	11	9	-	29.4
17	3.80	DS	SIL	2	2	17	1	66.7	9	2	-	33.3	2	4	16	2	75.0	6	2	-	25.0
2	2.50	SIL	3/4	-	-	-	-	-	2	1	1	100.0	-	-	-	-	-	1	-	-	100.0
8	5.00	3/4	SIL	-	-	5	-	29.4	7	3	2	70.6	-	-	12	2	60.9	3	6	-	39.1

DARK FULL SILVERS MATED TO LESSER SILVERS

31	4.58	DS	3/4	-	6	24	5	46.0	15	25	1	54.0	1	4	16	7	42.4	22	15	1	57.6
53	4.49	3/4	DS	1	3	33	11	36.1	38	44	3	63.9	2	10	47	13	68.6	18	14	1	31.4

THREE-FOURTHS SILVERS MATED TO LESSER SILVERS

1	5.00	3/4	1/2	-	-	-	-	-	1	2	1	100.0	-	1	-	-	100.0	-	-	-	-
3	6.00	1/2	3/4	-	-	3	-	27.3	-	8	-	72.7	-	-	1	3	57.2	2	1	-	42.8



# INHERITANCE OF SILVERING IN FOXES

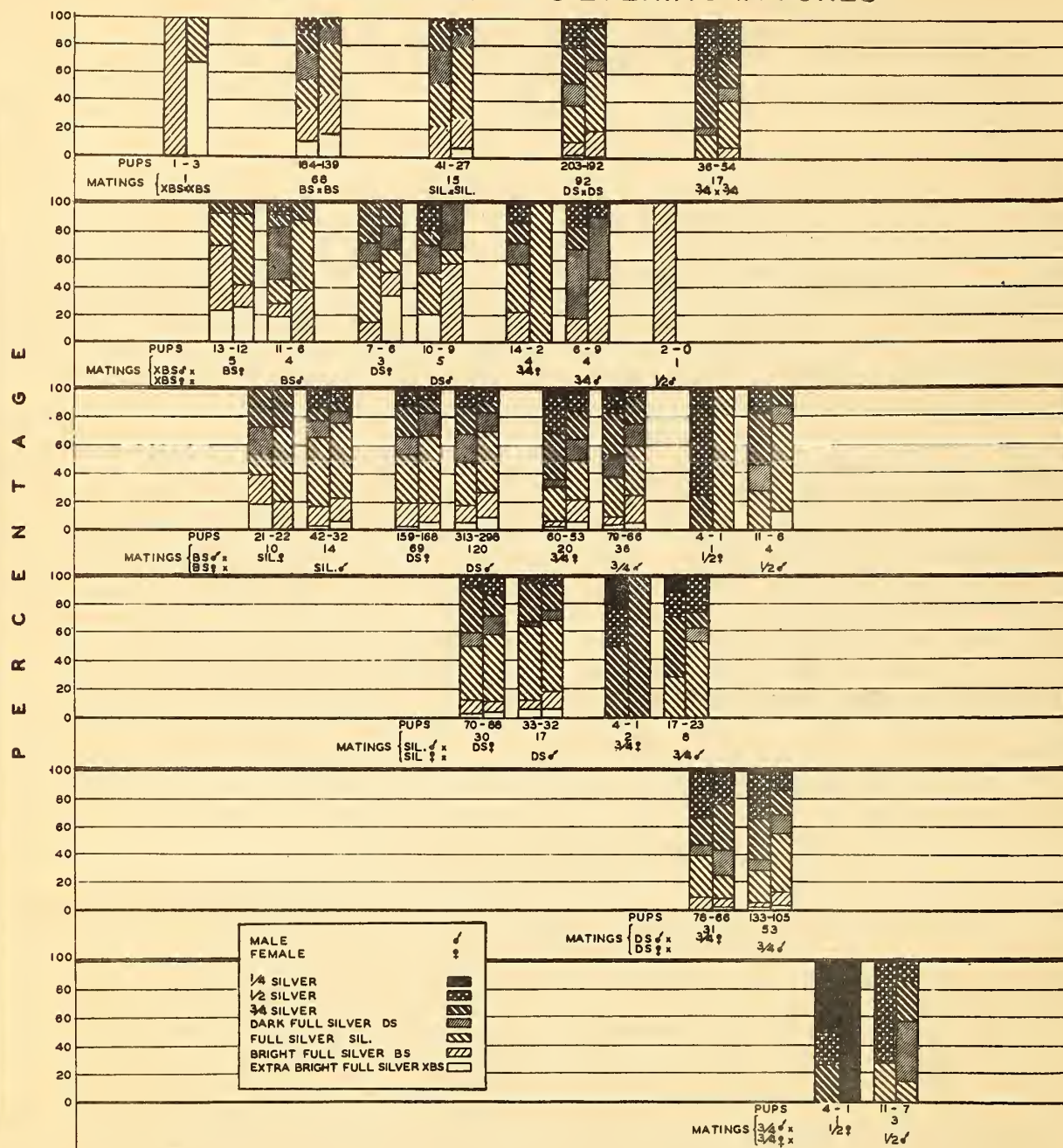


FIGURE 1.--Percentage distribution, according to degree of silvering, of pups resulting from 638 matings of silver foxes of various degrees of silver. Information on male pups is shown in the left-hand, and on female pups in the right-hand, column of each pair. The number of pups is given under each column, and the number and kind of matings under each pair of columns.

The 1935 and 1936 matings and the resulting progeny are listed, according to degree of silver, in table 1. This tabulation is based on the records of 638 matings and may include data on two litters of pups from the same pair. The data are also segregated by sex of pups to determine possible variation in the inheritance of silvering. Reciprocal matings--the sexes reversed according to degree of silver--are grouped together for ready comparison. The columns headed "SIL" include all the pup pelts sold as full silver as well as the few animals retained for breeding that had a degree of silver that made them darker than the extra bright and bright full silver but lighter than the dark full silver. No doubt some of the pelts sold as full silver were extra bright, bright, or dark full silver, as no such subclassifications of full silvers were made in the market at that time.

The percentage distribution, according to degree of silvering, of the pups resulting from the 638 matings of silver foxes of various degrees of silver is shown graphically in figure 1. Columns showing results of the mating of animals having similar degrees of silvering are placed at the top, and are so spaced as to allow for putting underneath them in relative positions, according to the theoretical average degree of silvering of both parents combined, the results of all other combinations of matings. For example, bright silver and three-fourths silver parents would have an average silvering less than that of extra bright and three-fourths silver parents; hence columns showing the silvering of the pups from the former mating are placed somewhat farther to the right. The left column of each pair represents the male pups and the right one the female pups. The number of male and of female pups produced from each kind of mating is shown under their respective columns, and the number of litters is centered beneath each pair of columns. Reciprocal matings are shown.

#### MATING DATA ANALYZED

It is evident from table 1 and figure 1, and it is in accord with expectations, that the darker parents tend to produce a higher percentage of darker progeny. It is also seen that pups lighter as well as darker than the parents can be obtained by the selective outcrossing system of breeding. Some bright silvers can be recovered from three-fourths silver matings and some three-fourths and half silvers from bright silvers. Fox breeders are aware of this fact. Data concerning the degrees of brightness of the full silver pups obtained from darker silver parents are not so abundant, however, because of the practice of pelting a higher percentage of such animals and thereby eliminating them from the breeding herd when there is a demand for the brighter silvers, and because auction companies prior to 1936 did not subdivide the full silvers in the sales.

In the groups having the greater number of vixens there is an indication that when the vixen is the brighter silver of the two parents, the percentage of pups showing full silver will be somewhat higher than when



the reverse cross is made (table 1). Also by grouping together all matings in which the vixen was the brighter parent, it was found that nearly 7 percent more of the female pups were full silvers than when the male was the brighter parent (table 2).

TABLE 2.--Comparison of the average size of litters and the percentages of full silver pups from matings in which the males are brighter silver than the females with those from the reverse matings

Kind of matings	Number of matings	Pups		Full silver pups	
		Total number	Avg. per litter	Males Percent	Females Percent
Males brighter silver than the females . .	176	832	4.73	56.5	71.0
Females brighter silver than the males .	268	1,235	4.79	58.2	78.0

There is no indication that the lighter silvers are necessarily less productive than the darker silvers (tables 1 and 2).

A higher percentage of the female pups at the Associated Fur Farms are full silvers--75 percent as compared with 58 percent of the male pups.

#### SECOND LITTERS ARE DARKER THAN THE FIRST

Many fox breeders believe that subsequent litters by the same pair tend to show less silver than the previous litters. In the present study there were not a sufficient number of records of the same pairs mating more than 2 years in succession to warrant any consideration. The records did contain data, however, on 170 pairs of foxes that produced two litters in successive years. All but about 10 of the vixens were 2-year-old animals at the time of the second whelping.

According to the degree of silver, there were 16 types of matings, including reciprocal crosses. When the male and the female pups were considered together, the percentage of full silver pups in the second-year litters in every case was lower than in the first. When the pups were segregated according to sex, however, of the possible 32 groups only 4 groups in the second year showed an increased percentage of full silvers over that of the first, these exceptions being female pups from bright



silver females mated to bright silver males; male pups from bright silver females mated to three-fourths silver males; female pups from three-fourths silver females mated to three-fourths silver males; and female pups from three-fourths silver females mated to dark silver males. Of the 420 male pups produced the first year from the 170 pairs, 66 percent (table 3) were full silvers, whereas of the 448 males whelped the second year, only 53 percent were full silvers--a decrease of 13 percent of full silvers the second year. Of the 398 female pups produced the first year, 78 percent were full silvers, and of the 385 females whelped the second year, only 68 percent were full silvers-- a decrease of 10 percent of full silvers the second year. In July the litters averaged 4.81 the first year, and 4.92 the second.

TABLE 3.--Distribution according to sex and degree of silvering of the pups in the first and second litters of 170 pairs of silver foxes

Degree of silvering	First-year pups			Second-year pups		
	Males (420)	Females (398)	Total (818)	Males (448)	Females (385)	Total (833)
	Percent	Percent	Percent	Percent	Percent	Percent
Full . . . . .	66.0	78.4	72.0	53.2	68.3	60.2
Three-fourths	22.8	14.3	18.7	23.2	18.2	20.8
Half . . . . .	10.7	7.0	8.9	21.2	13.0	17.4
Quarter. . .	0.5	0.3	0.4	2.4	0.5	1.6
Total	100.0	100.0	100.0	100.0	100.0	100.0

The full silver pups kept for breeding were further designated extra bright, bright, and dark, but there was such a great difference in the number of pups saved for breeding during the 2 years that a comparison of the percentage distribution on the basis of these finer divisions of full silver has little value. Full silver pelts, however, are not subdivided when marketed. The terms "three-fourths silver" and "half silver" are applied both to the marketable pelts and to the animals retained for breeding. In table 3 it will be seen that most of the increased percentage of the darker pups of the second year were half silvers. It should be kept in

mind that the accuracy of the figures depends on the uniformity with which the pelts and the animals were graded during the 2 years. The same person in both years classified the pups retained as breeders and the pelts sold, taking special care to keep the grading comparable.

In this particular case it was not possible to determine whether the difference that existed in the degree of silvering was due to the fact that the pups belonged to successive litters or to the fact that the first-year litters were almost entirely from yearling vixens. The difference in the degree of silvering in the pups of the first 2 years may be greater than in those of any subsequent 2 years. It would be interesting to know whether the older vixens produce pups as much darker in successive years as the yearlings did in this case. Yearlings whelp considerably later than the older vixens do, and there may be other differences not as yet discovered. Intensive inbreeding might not yield results comparable with the data herein given.

If vixens regardless of age do produce darker pups in each successive year, what is the cause? Is it due to some accumulated deficiency in the feed or to something outside the field of nutrition? If the maximum decrease in silvering occurs in the second-year litters, what is the explanation? What is the nature of the change? It is<sup>a</sup> rather common belief among fox men that with advancing age the individual animal tends to show less silver. The cause and nature of this change, if it does occur, are intriguing.

#### POSSIBLE GENETIC EXPLANATION

A clear genetic explanation of the phenomena revealed by this study is not at present possible, but if conditions in the fox are similar to those in other mammals, it seems most probable that a number of genetic factors, or genes, affect silvering in the fox. These genes are probably on many different chromosomes, and various types of genetic interaction no doubt occur. Some of the genes for silvering are probably carried on the sex (or X) chromosome, and the lighter silvering observed in female pups may be due to this, since the X chromosomes occur in pairs in the female and singly in the male. If a major gene or several genes for silvering are carried on the X chromosome and if there should be cumulative action of these genes, it might account for the lighter silvering generally observed in the female pups, since these genes would occur in duplicate in the female and singly in the male. This is problematical, however, and only prolonged research will reveal the facts.

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